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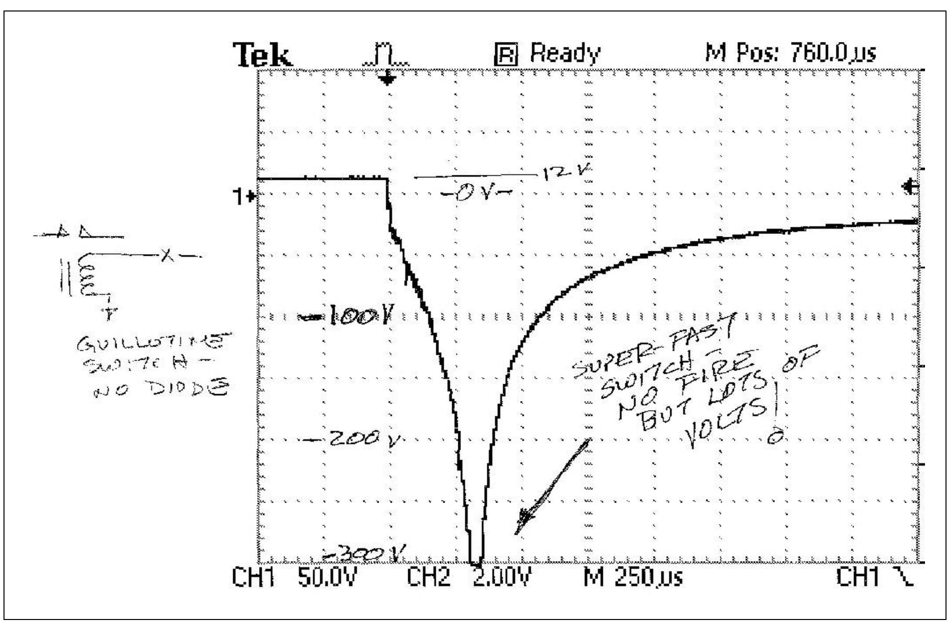
Spike Catching Diodes - Fables and Facts

There’s a lot of mis-information circulating around the aviation community as to whether or not and how a spike-catching diode should be included in the circuit controlling the coil of any large relay, contactor or other inductive load. A reader comments on the practice of putting diodes across the coil of a contactor . .

> A diode connected in this way is usually suggested to clamp the inductive
> voltage spike resulting from de-energizing the relay coil. The problem is
> that it provides a path for the current caused by the collapsing magnetic
> field. The net result is that the amount of time it takes to open the
> relay *increases*. This exacerbates the issue of a sticking relay in that
> a slower release time causes more arcing at the contacts.

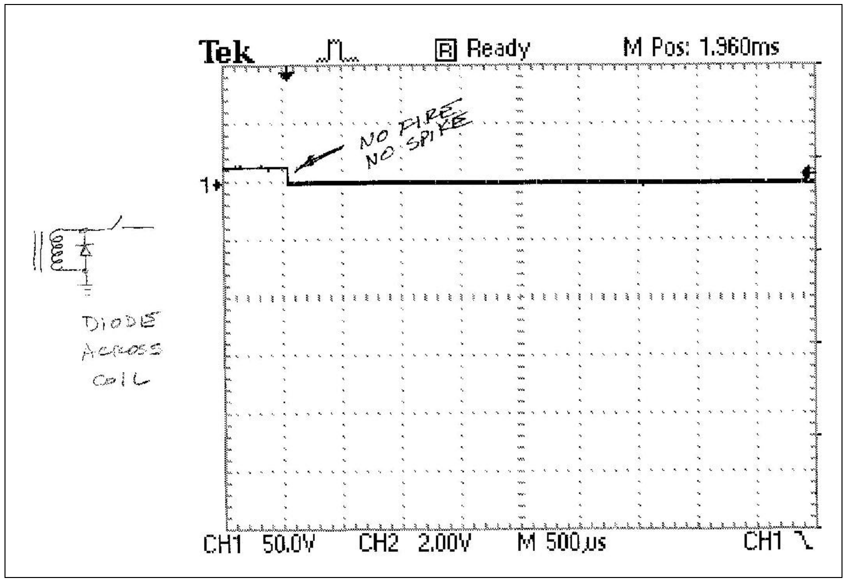
Yeeeaaahhh BUT . . . I've never been able to document much change in the contact spreading velocity of the contactors we sell when the recommended diode is included in the coil circuit. I have been able to document wear and tear on the switch that controls the contactor and it's much worse if the diode is left off.

On starter contactors, the spring tension that opens contacts is MUCH larger than for the continuous duty contacts. Further, given the higher coil current, it's more important that this stored energy be calmly dealt with than with battery contactors. Hence, our starter contactors come with the diode BUILT IN. I have to believe that the folks who make these by the millions for ground based vehicles find this a useful thing to do.



The figure at the left illustrates a typical stored energy dump from one of our S701-1 Battery Contactors. To make this measurement exclusive of switch effects, I strung a piece of 22AWG wire between two c-clamps with a LOT of rubber bands holding the wire in tension.

Cutting the wire provided a “switch contact” opening velocity many times faster than ordinary hand operated switch. The major feature of this figure is the very strong NEGATIVE going spike generated by the collapsing magnetic field in the contactor. It’s very strong (300 volts or more) and if allowed to expire on its own, lasts for a couple of milliseconds. Note also that the slope of the negative going waveform is about .6 volts per microsecond.

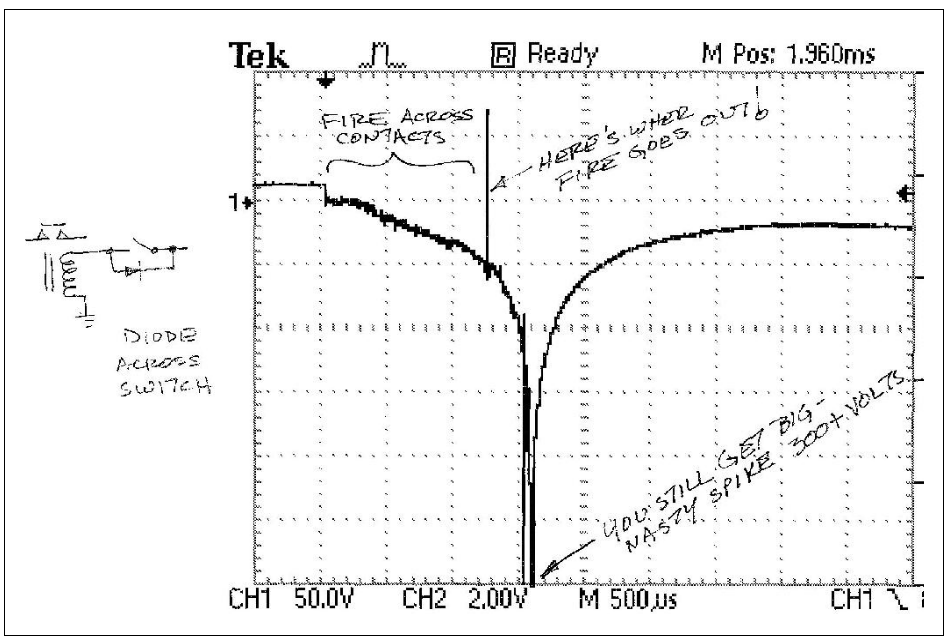


Common practice for years has been to place a diode across the contactor’s coil that would conduct heavily and stop this spike from propagating out to the rest of the system. Here’s what happens when you add the diode. Here I used one of our plain-jane toggle switches to control the contactor. Notice in the figure above that nothing noteworthy happens when the switch opens. Voltage across the coil falls to zero and stays there. No fire, no spike.

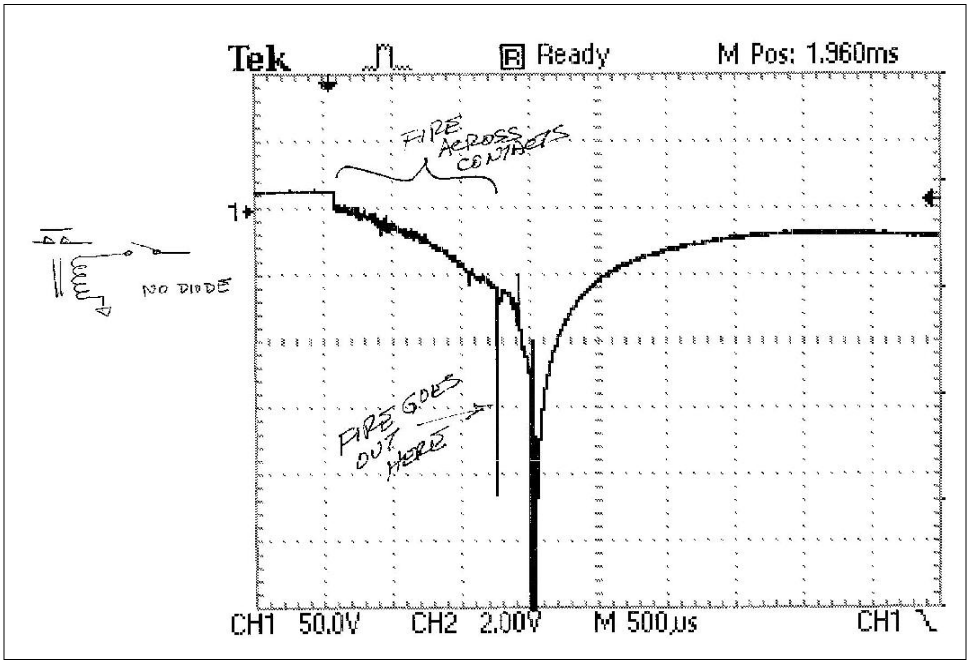
Another comment on the list-servers about spike catchers suggests:

> A better way is to dump the current of the collapsing field into the
> battery. You can do this by connecting the diode across the starter
> switch (cathode band to the battery side of the switch) rather than the
> coil. This is a higher impedance path, and it allows the coil magnetic
> field to collapse faster while still clamping the voltage.

Okay, let’s try it:



When the switch opens, notice that the change in voltage for 1.2 milliseconds has a slope of .04 volts per microsecond or about 15 times SLOWER than the slope of waveform in the first figure. This is because as the contacts of the switch open, a tiny but very hot electrical fire starts between the spreading contacts of the switch. This flow of current through the switch AFTER the switch opens slows the rate-of-change for the waveform. Note that the diode didn't do anything for us because the output from the coil is negative going . . . in a polarity opposite to that which the diode would be expected to catch.



Hmmmm . . . just for grins, let's take the diode off completely and leave the toggle switch in place. Here's what we get:

Note that the waveform isn't much different than what we got with the diode across the switch. Same fire, same spike.

A few years ago, an AD was issued against the key-type OFF-L-R-BOTH-START switch manufactured by Aircraft Spruce. The intent of the AD was to repair excessively worn contacts in the switch that control the starter contactor. The mechanic was tasked with disassembly of the switch and replacing burned contacts. A diode was include with the kit with instructions to install it across the switch contacts when the assembly was put back into the airplane.

The demonstration above tell us that adding the diode in that manner would have no beneficial effects on switch contact life. Let's head off another myth at the pass . . . many folk would look at the pictures above and shudder at the idea of 300 volt "spikes" roaring about the airplane wreaking havoc along the way. The energy from a collapsing contactor coil is going to be used up in where ever the circuit resistance is greatest - ACROSS THE OPENING CONTACTS OF THE CONTROLLING SWITCH. A tiny fraction of it might make it out onto the bus but not enough to be a significant threat to any other system components. Adding the diode benefits the controlling switch. The rest of the system doesn't care if the diode is there or not.

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